UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

TECHNICAL LETTER NUMBER 40

HIGH-FREQUENCY CONTENT OF SPECIAL RECORDINGS--

PROJECT LONGSHOT*

by

John H. Healy** and Wayne H. Jackson**

[redacted]

DENVER, COLORADO

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Technical Letter
Crustal Studies-40
November 15, 1965

Dr. John DeNoyer
VELA UNIFORM Branch
Advanced Research Projects Agency
Department of Defense
Pentagon
Washington 25, D. C.

Dear Dr. DeNoyer:

Transmitted herewith are 10 copies of:

TECHNICAL LETTER NUMBER 40

HIGH-FREQUENCY CONTENT OF SPECIAL RECORDINGS--

PROJECT LONGSHOT*

by

John H. Healy** and Wayne H. Jackson**

Sincerely,

John H. Healy
by D J Stuart

John H. Healy, Chief
Branch of Crustal Studies

* Work performed under ARPA Order No. 193-65.

** U. S. Geological Survey, Denver, Colorado.

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INTRODUCTION

Recent interest in the high-frequency content of teleseismic signals led us to try a simple experiment for LONGSHOT. Three recording trucks, designated PAPA, TANGO, and SIERRA, were stationed along a line at 4-km intervals in the Golden Gate Canyon (Ralston Buttes quadrangle) to the west of Denver (Figure 1). A combination of EV-17 (1 cps) geophones and filter settings were used in an attempt to get the high-frequency portion of the signal on magnetic tape with sufficient dynamic range for analysis. Most of the existing stations are set to record teleseismic signals of about 1 cps and even when the data is on tape, there is usually an inadequate dynamic range to examine the high-frequency content.

Samples of monitor records (Figures 2, 3, and 4) show characteristic teleseismic arrivals at different filter settings. These records were played back on a time-compressed scale using high-cut filtering to remove the high-frequency noise (Figure 5). One of the most outstanding events on the record is an exceptionally strong P_cP recorded within a few seconds of the time estimated by the Jeffreys-Bullen curves. The first arrivals are clear and show a clear upward motion for the first break.

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Even though the three stations were within a few kilometers of each other, there are marked differences in the characteristics of the seismograms following the first arrivals, which are probably caused by complex crustal structure in the region which is close to the transition zone between the Great Plains and the Rocky Mountains.

High-frequency content of the seismic signal.--One of the stations was disturbed by the passage of an automobile, but this disturbance was limited to a few seconds of the total record. A more serious high-frequency disturbance was created by aircraft at the time of the shot which is particularly evident on TANGO and SIERRA (Figures 3 and 4). Even with these disturbances, the sites would be classified as exceptionally quiet.

Techniques involving spectral analysis are often employed to examine the high-frequency content of seismic signals. These techniques have certain inherent disadvantages which may prevent meaningful determinations of high-frequency content. In particular the choice of a window length presents a serious problem because it is very difficult to avoid introducing a section of the record longer than the section containing the phase being analyzed resulting in the introduction of high-frequency noise from outside the time duration of the arrival. The application of time domain filtering avoids this difficulty.

The playback system designed for the analysis of crustal data was used in an attempt to extract the high-frequency portion of the seismic signal. A representative sample of the playbacks are compiled in Figure 6. The filtering was applied to the trace which had been recorded with a 3-1/2 cps low-cut filter and a 37 cps high-cut filter. These filters have slopes of 18 and 36 db per octave respectively. The filter settings used on playback have slopes of 54 db per octave. There was no combination of filters which would reveal energy above the background noise level with frequencies higher than about 4 cps. The filter settings with low-cut out and a high-cut of 2.5 cps applied to the record that had been recorded with a 3.5 cps low-cut filter reveal significant energy with a frequency of about 3 cps.

Amplitude-frequency relationships for the first few cycles of the prominent P phases, together with the background noise levels, are plotted in Figure 7.

CONCLUSIONS

The ability to extract energy from the LONGSHOT event with an instrumental frequency response from 3 to 4 cps suggests that significant information might be extracted from teleseismic signals by systems designed to work in this portion of the spectrum. The examination of other paths using different source and receiver positions are required to estimate the validity of the phenomena on a regional basis. Oliver (personal communication) has reported significant energy as high as 30 to 40 cps along some Atlantic paths and suggests that regional differences in the upper mantle characteristics may play an important role in establishing the high-frequency content of teleseismic signals. While it is too early to suggest possible uses of this portion of the spectrum in the detection problem, one can make the general statement that the high-frequency part of the spectrum may contain important information about the source mechanism that cannot be retrieved from standard teleseismic records.

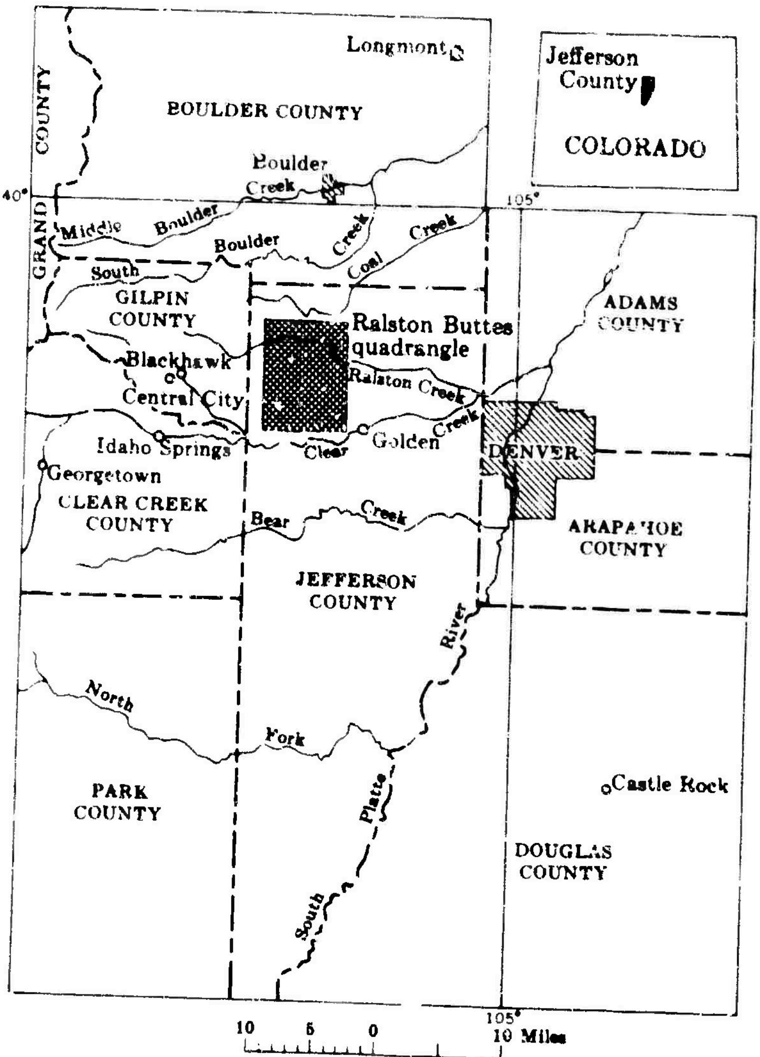

FIGURE 1. INDEX MAP SHOWING LOCATION OF RALSTON BUTTES QUADRANGLE, JEFFERSON COUNTY, COLORADO

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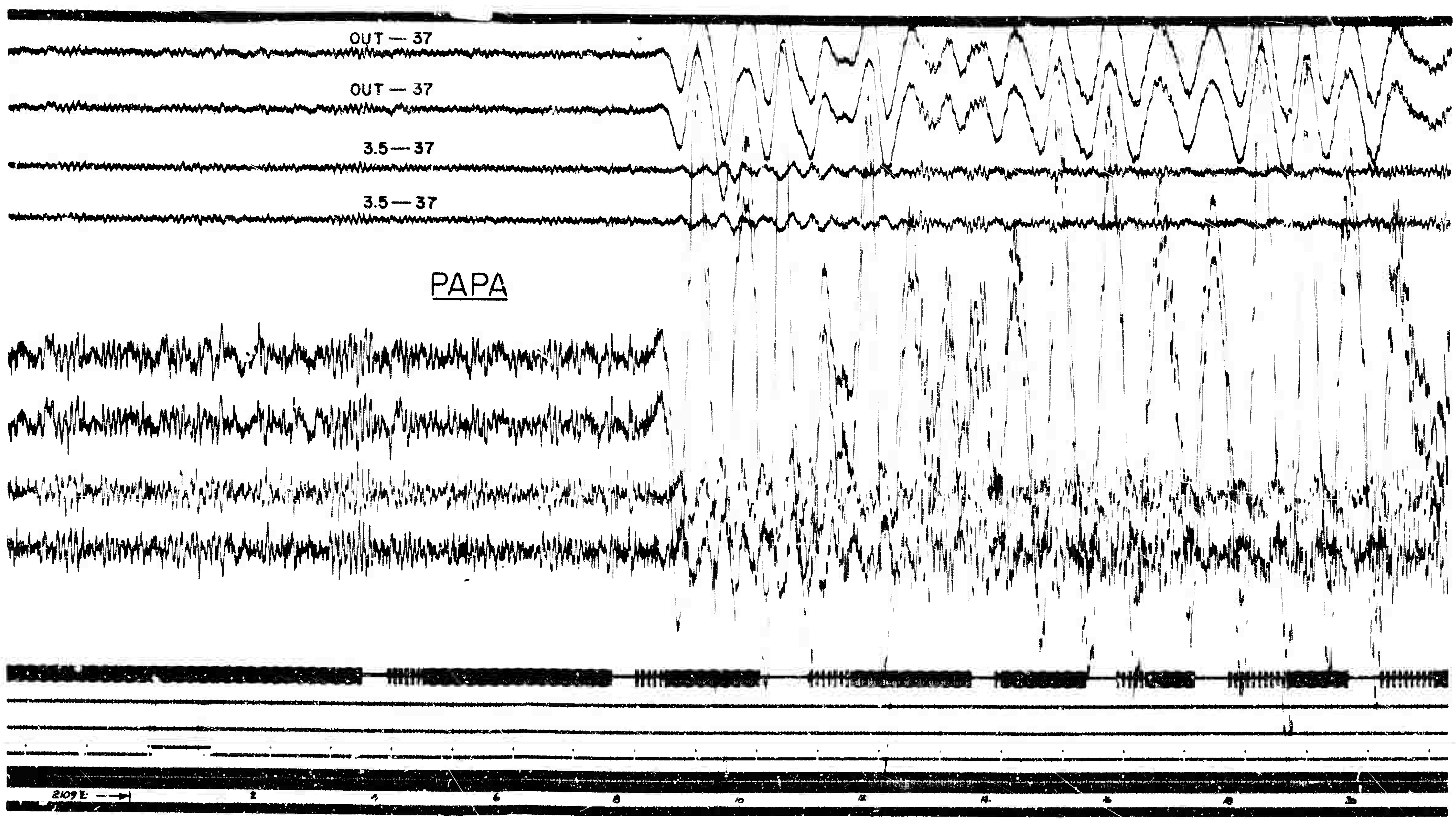


Figure 2.--Monitor record from unit PAPA. The numbers represent low- and high-cut filter settings.

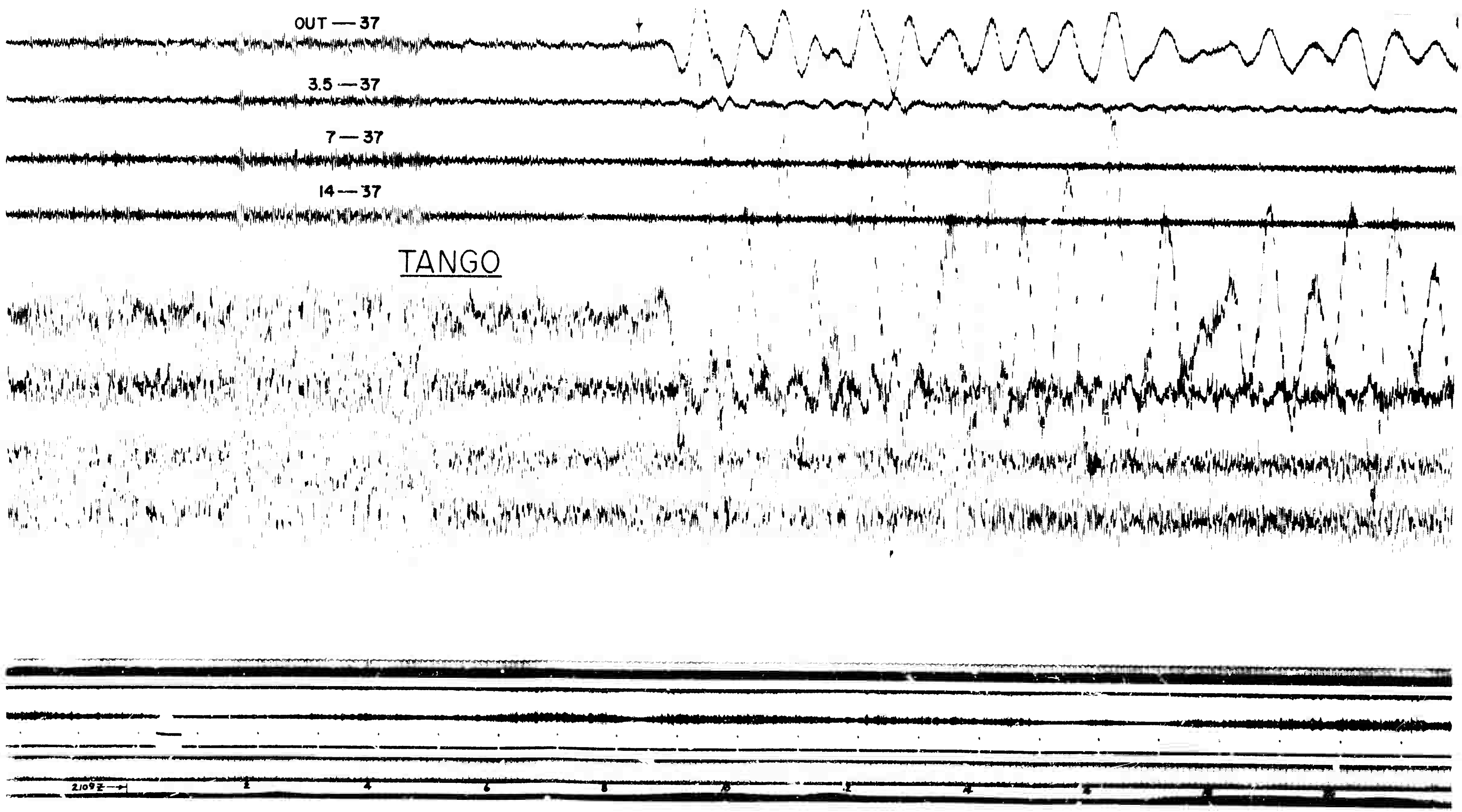


Figure 3.--Monitor record from unit TANGO. The numbers represent low- and high-cut filter settings.

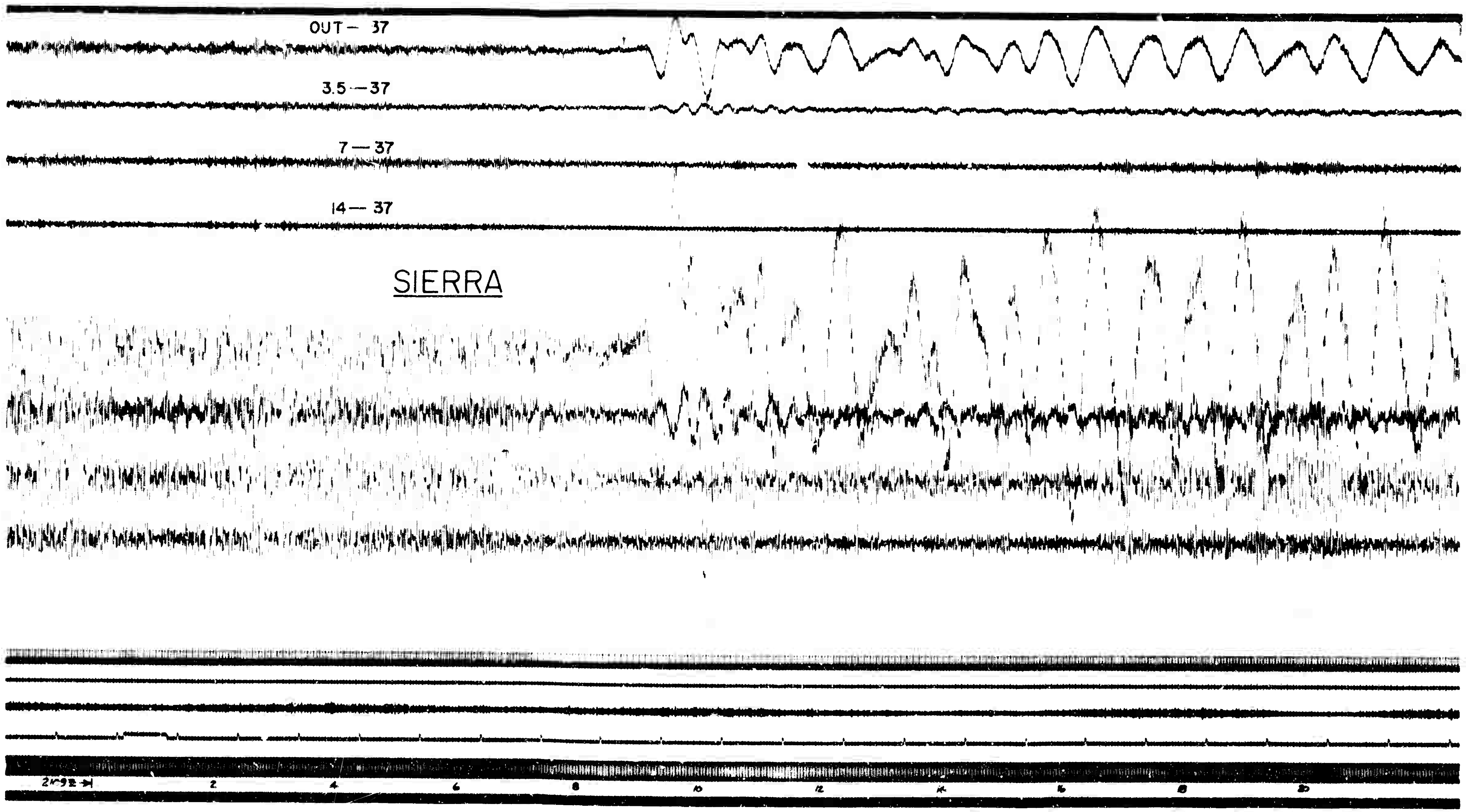


Figure 4.--Monitor record from unit SIERRA. The numbers represent low- and high-cut filter settings.

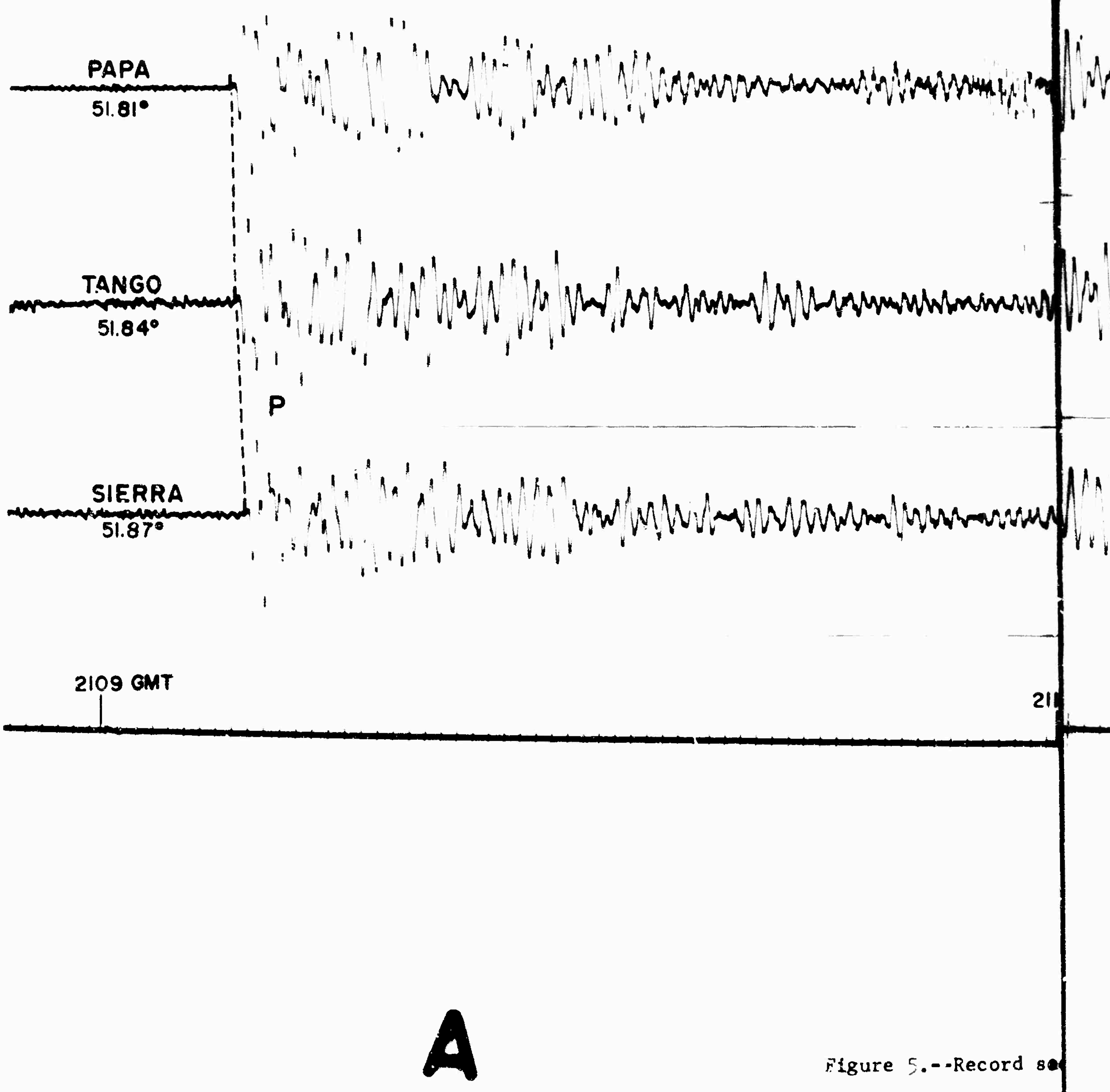


Figure 5.--Record se

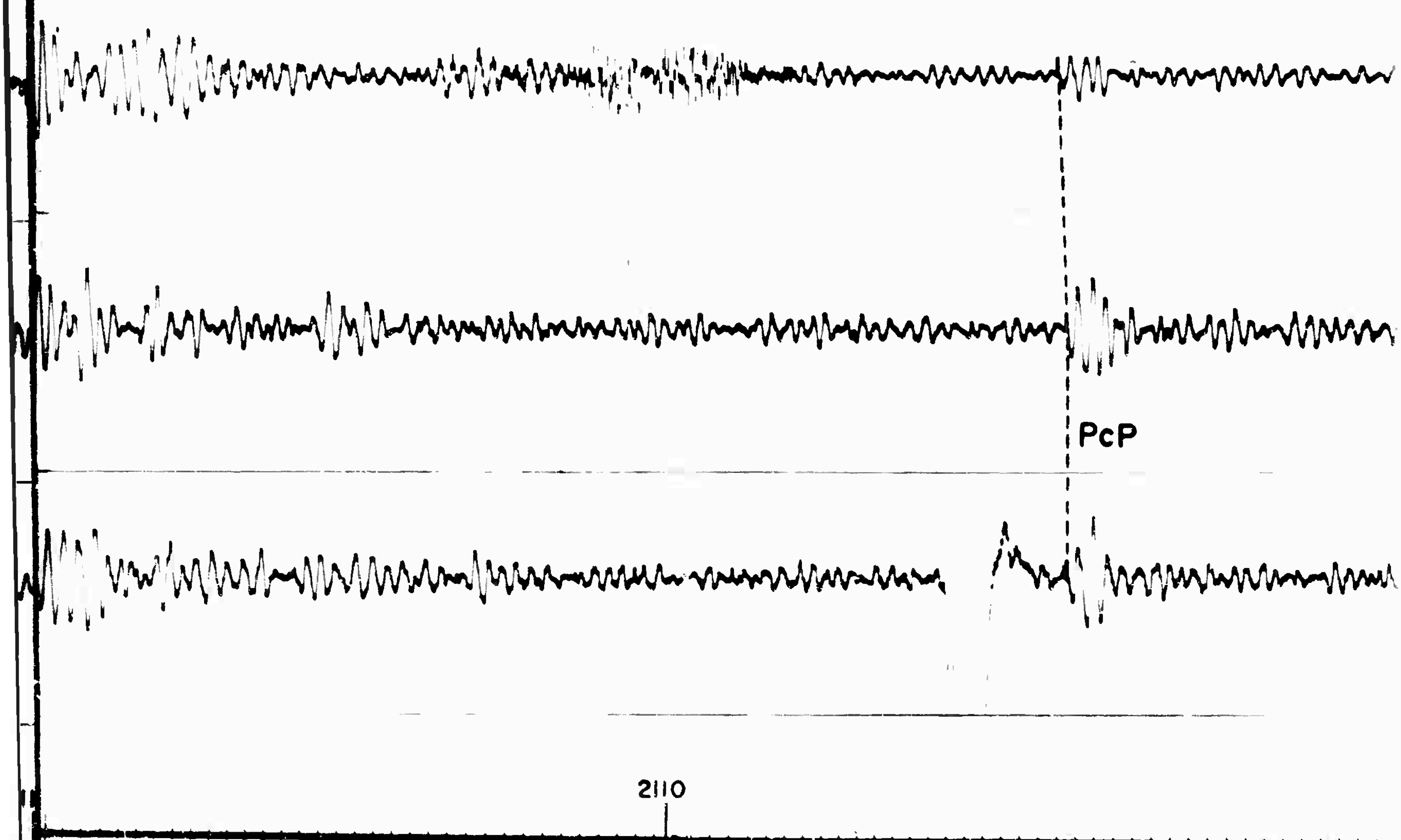
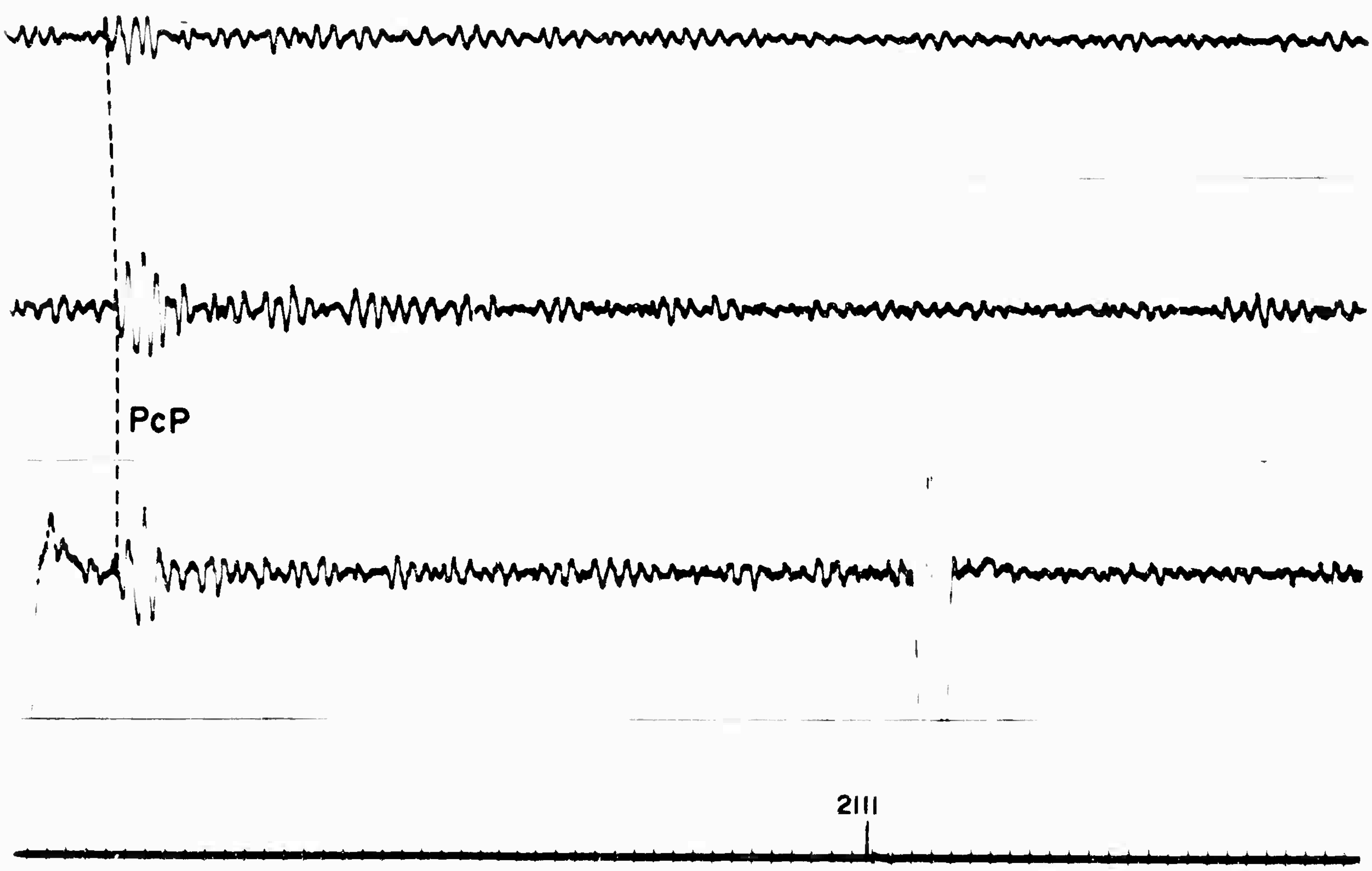


Figure 5.--Record section using channel 1 from PAPA, TANGO, and SIERRA.

B



rom PAPA, TANGO, and SIERRA.

C

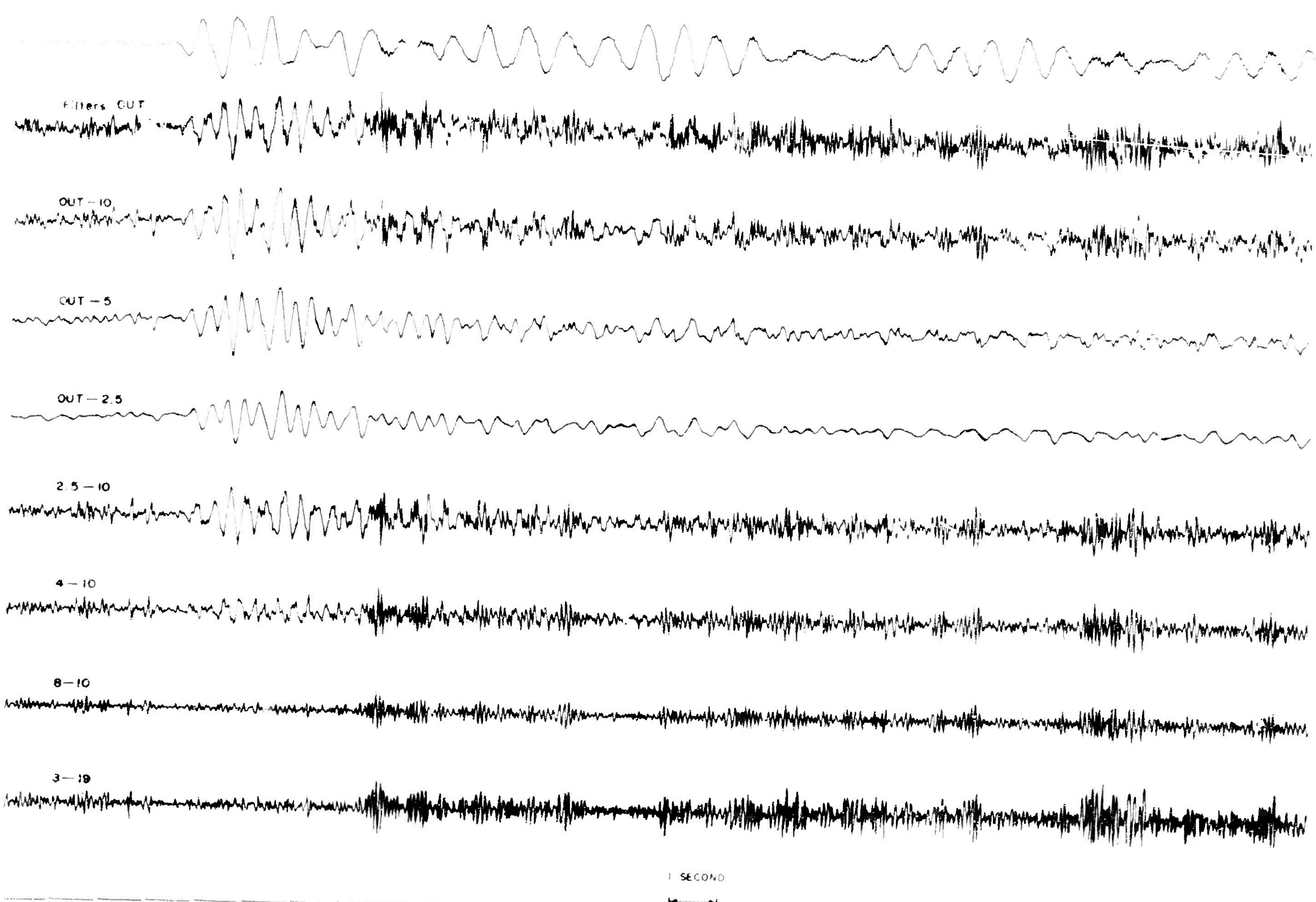


Figure 6.--Playbacks of unit PAPA's recording with various filter settings. Trace 1 is the unfiltered playback of channel 1 (see monitor); remaining traces are playbacks of channel 3.

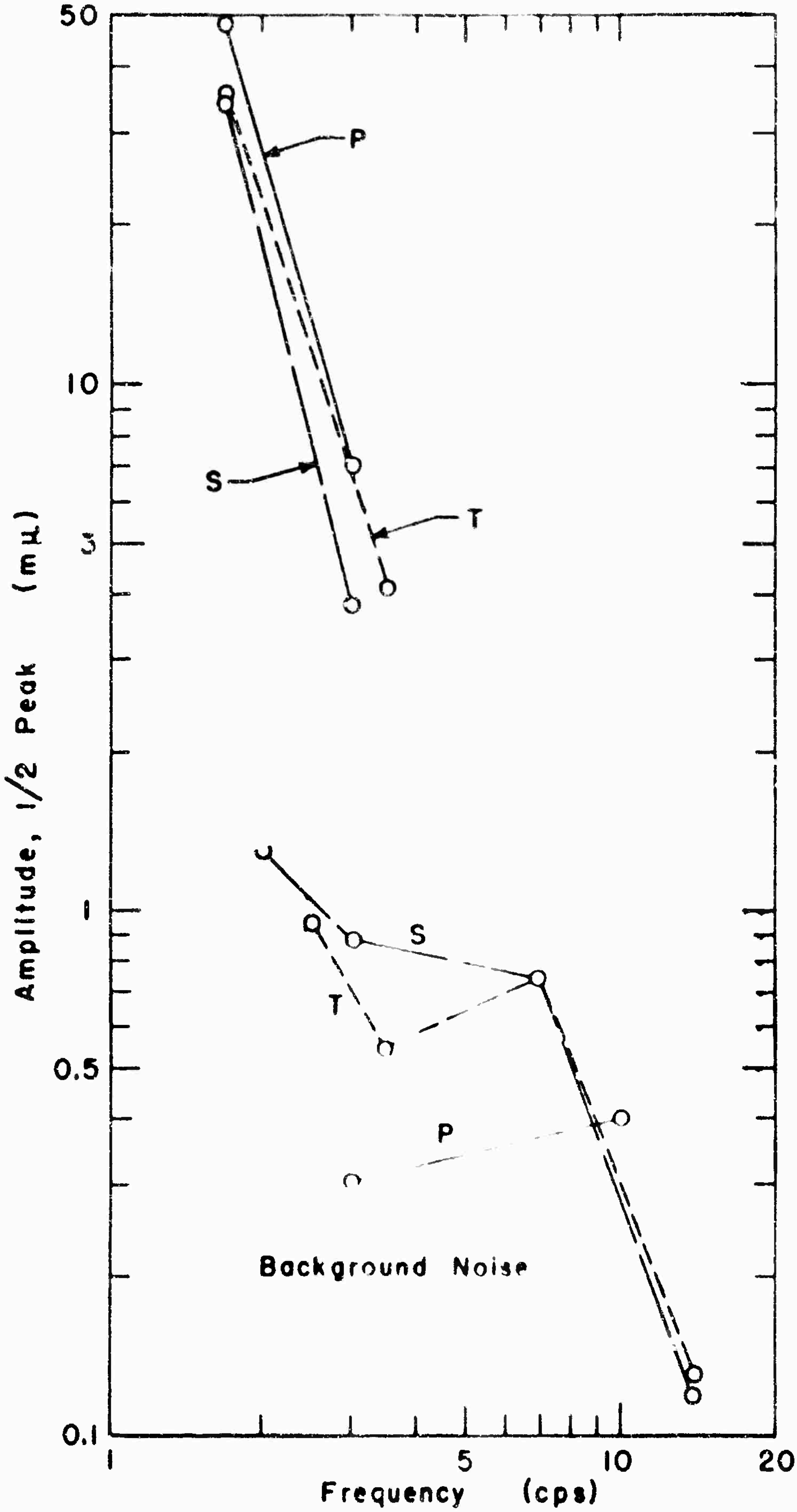


Figure 7.--Measured amplitudes of background noise and the first P event for units PAPA (P), SIERRA (S), and TANGO (T).